# 30.0 CALIFORNIA CENTRAL VALLEY SPRING-RUN CHINOOK SALMON ESU

## 30.1 BACKGROUND

### 30.1.1 Description of the ESU

The Central Valley spring-run chinook (CVSC) salmon evolutionarily significant unit (ESU) includes all naturally spawned populations of spring-run chinook salmon (and their progeny) in the Central Valley. Extant spring-run populations in the southern Cascades ecoregion include those in Mill, Deer, and Butte creeks (BRT 2003). Spring-run populations of the northern Sierra ecoregion are found in the Yuba and Feather rivers. The Feather River population is thought to depend on the Feather River Hatchery (FRH) spring-run artificial propagation program, which may also influence the Yuba River population. The FRH spring-run program is not part of the CVSC ESU (BRT 2003).

### 30.1.2 Status of the ESU

The CVSC ESU was listed as threatened on September 16, 1999 (64 FR 50394), due to the loss of approximately 95% of historical steelhead spawning habitat (Yoshiyama *et al*. 2001), the severe degradation of remaining rearing and migration habitat, and the possible hybridization of spring- and fall-run chinook salmon from operations at the Feather River Hatchery (64 FR 50394; CDFG 1998). Hydropower projects have impacted stream hydrology and barred access to cool, deep pools required by spring-run for holding over in the summer. Unscreened water diversions, fish predation, and high water temperatures also continue to threaten spring-run (BRT 2003). The CVSC ESU had been reduced from an estimated peak of 700,000 spawners (Fisher 1994) to a range of 67 to 243 spawners per population by the mid-1980s (BRT 2003). Only three out of 18 historical spring-run populations still exist. All of the San Joaquin River Basin spring-run populations have been extirpated by the loss of their habitat, high water temperatures, and lack of flows (CDFG 2002; BRT 2003). More recent population estimates (years 2001-2003) for upper Sacramento River spring-run indicate increasing abundance for the Mill Creek (1,426), Deer Creek (2,759), and Butte Creek (4,398) populations. The 2003 estimates of spring-run in streams dependent upon migration from adjacent populations range from 25 to 94 fish (CDFG 2004). The long- and short-term trends for spring-run growth have been positive over the past five years (BRT 2003). The evolutionary path of Feather River spring-run and its genetic relationship to the Feather River and other Central Valley fall-run populations reflects a different pattern from that of the southern Cascades spring-run populations in the upper Sacramento River basin. Nevertheless, it appears that the Feather River and FRH spring- and fall-run populations no longer demonstrate a temporal separation between runs (BRT 2003). Hatchery fish and progeny may express either spring- or fall- run timing, and for this reason, the FRH spring-run chinook salmon program is not recommended for inclusion in the CVSC ESU. Recent information (CDFG 2003) on Yuba River Chinook salmon supports an expression of spring-run ("early-run") timing. Approximately 108 fish moved past Daguerre Point Dam from March 1 through July 31 in 2002; in 2000, 168 spring-run chinook salmon redds were documented in the 10-mile Garcia Gravel Pit Reach below Oroville Dam. Analysis on Yuba River salmon tissues

has genetically linked the spring-run and fall-run populations, which exhibit a merged run timing similar to that found in the Feather River. A majority (69%) of the West Coast Biological Review Team (BRT) members voted that this ESU is "likely to become endangered," 27 percent Voted that the ESU is "in danger of extinction," and 4 percent voted that listing was "not warranted." The BRT expressed moderate to high concern for ESU abundance, spatial structure, and diversity and moderate concern for ESU productivity.

## 30.2 ASSESSMENT OF THE HATCHERY PROGRAM

There is one hatchery program operated at the FRH that releases out-of-ESU spring-run chinook salmon into the CVSC ESU. The following section presents a summary of the broodstock history, similarity between hatchery-origin and natural-origin fish, program design, and program performance of the artificial propagation program.

**Table 30.1 –** Artificial propagation program that releases steelhead within the geographical area of the California Central Valley Spring-run Chinook ESU.

| Program | Type | Included in ESU | Description | Production Level | Year Initiated |
|---|---|---|---|---|---|
| Feather River Hatchery | integrated | no | yearling smolt | 5,000,000 | 1967 |

### 30.2.1 Spring-run Chinook Salmon Population/FRH Spring-run Program

The Feather River spring-run chinook salmon population was estimated to number 2,000 adults in 1946 (Fry 1961), ranging from 500 to 4,000 before complete blockage from Oroville Dam (Mahoney 1958, 1960). Numbers dropped to 146 fish in 1967, the first year of spring-run trapping at the FRH. It is speculated that introgression of Feather River spring-run and fall-run chinook salmon may have begun with early hydropower and agricultural diversions blocking access to spring-run spawning habitat in the upper watershed (CDFG 1998). This process has also been fostered by the construction of Oroville Dam and FRH broodstock collection practices, leading to a hybridized genome in both natural and hatchery chinook salmon. An intermixed life history pattern was demonstrated by a restoration action on Clear Creek, in which tagged FRH spring-run planted as juveniles returned as "fall-run" adults (CDFG 1998). Allozyme analysis shows the Feather River hatchery and natural spring-run populations and Yuba River spring-run chinook salmon are part of a cluster composed mostly of natural and hatchery fall-run chinook salmon (NOAA Fisheries 1998). Hedgecock's (2002) analysis, using 12 microsatellite markers, found some distinction between the Feather River spring-run and fall-run, but spring-run were genetically much closer to the Feather River fall-run than to spring-run populations in Mill, Deer and Butte creeks. Hedgecock defined "early-running" and "late-running" chinook salmon populations in the Feather River that were otherwise genetically homogenous (BRT 2003). Currently, the FRH spring-run program is being managed to create a temporal separation between the FRH spring-run and fall-run programs. Alternatives for a long-term solution to spring-fall hybridization include spatial isolation of the two runs of chinook salmon by placement of a weir in the Feather River and passage opportunities for spring-run above Oroville Dam. The FRH spring-run program is not part of the CCVS ESU.

#### 30.2.1.1 Program History

From 1962 to 1966, spring-run chinook salmon were trapped and trucked above Oroville Dam. Beginning in 1967, spring-run chinook salmon were collected for artificial propagation at FRH as the construction of Oroville Dam was completed. The program is funded by the California Department of Water Resources and managed by the California Department of Fish and Game (CDFG).

The program was founded with local native stock collected at the hatchery. Early attempts to over-summer spring-run at the hatchery resulted in high mortality and the decision to allow the run to hold in the river until September 1. Before 2003, spring-run chinook salmon were collected in the hatchery through September 15 and spawned until October 7. Fish collected and spawned after those dates were considered to be fall-run chinook salmon. The new experimental collection protocol involves leaving the hatchery ladder open through May to allow early-running chinook salmon entrance to the hatchery. All fish are tagged for identification as spring-run broodstock and released to hold in the river until ready for spawning in the fall. Upon re-opening of the ladder in late August, the hatchery will spawn only tagged fish for spring-run production.

#### 30.2.1.2 Similarity between Hatchery-origin and Natural-origin Fish

There is a continuous presence of adult chinook salmon in the Feather River from May through October that is composed of the spring and fall runs. The FRH has defined the two hatchery stocks by a date chosen to assure adequate broodstock for the spring-run program, resulting in the expression of both spring- and fall-run timings in each hatchery program stock (BRT 2003). The Feather River migration is distinguished by an “early” and “late” run, which has merged to form a consecutive run timing distribution (Hedgecock 2002).

#### 30.2.1.3 Program Design

The mitigation goal for the spring-run chinook salmon program is the production of 5,000,000 fish at 60/lb. for release from May through July (SSHAG 2003). Up to 7,000,000 eggs may be collected for the program. Program fish are 100% adipose fin-clipped and CWT. Half of the production is currently released in-river, and the remainder is trucked for release into San Pablo Bay. The program was designed for harvest, and fish have been taken in commercial fisheries and recreational angling opportunities.

#### 30.2.1.4 Program Performance

Hatchery stock may exhibit either spring- and fall-run timing and cannot be utilized in either run-specific studies. In addition, 50% of hatchery production is trucked to San Pablo Bay for release, increasing fish survival but encouraging variable straying among hatchery adult returns (CDFG and NOAA Fisheries 2001). Possible straying and hybridization of program fish with local native fish stocks present significant risks to the CVSC ESU (CDFG 1998; CDFG and NOAA Fisheries 2001). FRH has been unable to meet its production goal of 5 million yearling smolts, but it

appears that a production goal of 2 million spring-run would be closer to the historical spring-run numbers above Oroville Dam (CDFG 1998). The FRH spring-run chinook salmon program has successfully provided for a recreational fishery in the Feather River.

#### 30.2.1.5 VSP Effects

***Abundance*** – It is difficult to determine the contribution of the FRH program to the abundance of spring-run in the Feather River. Both spring and fall runs occur simultaneously in the river and share spawning habitat. Surveys in the Feather River attribute all recovered salmon carcass data to fall-run chinook salmon. There may be some future evaluation of hatchery contribution to the natural spring-run spawning population with the first year of returning marked spring-run hatchery fish. FRH spring-run are not part of the ESU and do not contribute to ESU abundance.

***Productivity*** – The FRH hatchery spring-run is genetically linked to the in-river spring/fall-run population, and has contributed to the productivity of the river population. There are no studies on the productivity of the Feather River hatchery and natural stocks. The straying of FRH stock is a risk to the ESU, because its mixed genetic lineage could impact the life history of spring-run populations in the ESU.

***Spatial Structure*** – FRH spring-run have been released into various tributaries in the Sacramento River, including the Feather River. They were trucked to San Pablo Bay beginning in the 1980s. Returning adults have been recovered throughout the Central Valley. The highest spring-run returns back to the hatchery are from in-river juveniles releases (CDFG 1998). Straying chinook salmon adults may pose demographic risks to native local spring and fall-run populations.

***Diversity*** – The CVSC ESU encompasses populations exhibiting two evolutionary history patterns (BRT 2003). The FRH spring-run program represents one of two spring-run populations that evolved within the northern Sierra ecosystem. The spring-run hatchery stock introgressed with the fall-run hatchery stock, and both are genetically linked with the natural populations in the Feather River. There has been relatively little marking of hatchery production, but it is likely that natural fish are incorporated into the hatchery broodstock. The Yuba River has received several fish plants from the FRH, so there may be some genetic impact on the Yuba River spring-run within that system (BRT 2003). The FRH program has affected the diversity of the CVSC. The FRH spring-run program is not part of the CVSC ESU.

## 30.3 CONCLUSIONS

**Existing Status**: Threatened
**BRT Finding**: Threatened
**Recommendation**: Threatened

### 30.3.1. ESU Overview

#### 30.3.1.1 History of Populations

Spring-run chinook salmon populations at one time formed the dominant ESU in the Central Valley, inhabiting the headwaters of all major river systems in the Sacramento and San Joaquin river basins where natural barriers were absent (Yoshiyama *et al.* 2001). The only streams known to retain consistent spring-run returns since major dam construction in the Central Valley include Mill, Deer, and Butte creeks (the southern Cascades group) and the Yuba and Feather rivers (the northern Sierra group). The evolutionary patterns of the two geographic groups are distinct, and the unique genetic profiles of the Yuba and Feather River populations are at least partially attributed to their evolutionary history.

#### 30.3.1.2 Association between Natural Populations and Artificial Propagation

***Natural populations "with minimal genetic contribution from hatchery fish" –*** Based on allozyme and microsatellite analysis, the natural spring-run and fall-run chinook salmon populations in the Feather River have had a significant genetic contribution from FRH spring-run fish. There may also have been genetic contribution to the natural spring-run in the Yuba River from FRH fish plants (CDFG 1998).

***Natural[1] populations "that are stable or increasing, are spawning in the wild, and have adequate spawning and rearing habitat"[2] –*** The status and trend of the hybridized spring-run Feather River chinook salmon population is unknown because of the inability to distinguish early- from late-run timing in the carcass survey. The "fall-run" escapement to the Feather River has ranged from 100,000 to 200,000 fish over the past four years. All chinook salmon information collected in the Feather River has been attributed to natural fall-run population.

***Mixed (Integrated Programs[3]) –*** The FRH spring-run program has spawned all fish entering the hatchery during the designated spring-run returns to the Feather River. Until 2002, no spring-run were clipped, and there was no visual distinction between hatchery and natural fish.

[1] See HLP for definition of natural, mixed and hatchery populations

[2] HLP Point 3

[3] Integrated programs follow practices designed to promote and protect genetic diversity and only use fish from the same local population for bloodstock (both natural-origin fish, whenever possible, and hatchery-origin fish derived from the same local population and included in the ESU). Programs operated to protect genetic diversity in the absence of natural-origin fish (e.g., captive broodstock programs and the reintroduction of fish into vacant habitat) are considered "integrated."

***Hatchery (Isolated[4])*** **–** None.

## 30.3.2 Summary of ESU Viability

### 30.3.2.1 Abundance

The CVSC ESU has experienced a trend of increasing abundance in some natural populations, most dramatically in the Butte Creek population (BRT 2003). There has been more opportunistic utilization of migration-dependent streams. The FRH spring-run stock has also increased numerically, but this does not benefit the CVSC ESU because the hatchery stock exhibits the life histories of both spring- and fall-run chinook salmon.

### 30.3.2.2 Productivity

The 5-year geometric mean for the extant Butte, Deer, and Mill creek spring-run populations ranges from 491to 4,513 fish (BRT 2003), indicating increasing productivity over the short term that is projected as likely to continue (BRT 2003). As the FRH program is not part of the CVSC ESU, its productivity does not benefit the CVSC ESU.

### 30.3.2.3 Spatial Structure

Spring-run chinook salmon have been reported more frequently in several upper Central Valley creeks, but the sustainability of these runs is still unknown. Butte Creek spring-run cohorts have recently utilized all available habitat in the creek, so the population cannot expand further. It is unknown if individuals have opportunistically migrated to other systems. FRH spring-run chinook salmon that may reproduce outside the Feather River basin would be considered a risk to ESU populations because of their introgressed genome. The spatial structure of the CVSC ESU has been reduced with the extirpation of all San Joaquin River basin spring-run populations.

### 30.3.2.4 Diversity

Genetic analysis of natural and hatchery spring-run chinook salmon stocks in the Central Valley reveal that the southern Cascades spring-run population complex has retained its genetic integrity. The Feather River spring-run population has introgressed with the Feather River fall-run chinook salmon, and there is the possibility that the Yuba River population has been impacted by FRH plants, as well. Both populations are from the Sierra Nevada spring-run complex. The diversity of the CVSC ESU has been reduced with the genetic introgression of Feather River Hatchery spring-run and fall-run chinook salmon and the loss of the San Joaquin River basin spring-run populations.

[4] Isolated programs do not follow practices designed to promote or protect genetic diversity. Fish that are reproductively isolated are more likely to diverge genetically from natural populations included in the ESU and to be excluded themselves from the ESU.

### 30.3.3 Artificial Propagation Record

#### 30.3.3.1 Experience with Integrated Programs

Natural spring-run and fall-run have been incorporated into the program, as confirmed by allozyme and microsatellite analysis on FRH and Feather River Chinook salmon tissues. Both hatchery and natural fish are linked genetically to each other and to the Central Valley fall-run chinook salmon group.

#### 30.3.3.2 Data on Whether Integrated Programs Are Self-sustaining

In order to meet increasing production goals for the spring-run program, hatchery broodstock collection was extended an additional 10 days, and all chinook salmon entering the hatchery by September 15 were considered as spring-run. Chinook salmon entering the hatchery after this cut-off date were considered to be fall-run, so their progeny counted towards fall-run production goals. The 2004 FRH spring-run broodstock will be collected from 3700 chinook salmon adult returns previously tagged in May and June 2004, in an effort to establish a temporal separation between the spring-run and fall-run chinook salmon in the Feather River system.

#### 30.3.3.3 Certainty that Integrated Programs Will Continue to Operate

The FRH spring-run program is currently undergoing evaluation on its hatchery programs as part of the Oroville Project in a FERC relicensing process. FRH is attempting to re-create a discrete spring-run life history in the Feather River with an adaptive management approach on broodstock collection. Permanent alternatives, including spatial isolation of spring chinook in the Feather River by placement of a weir and spring-run passage above Oroville Dam, are being investigated.

### 30.3.4 Summary of Overall Extinction Risk Faced by the ESU

Spring-run chinook salmon have been extirpated from most of their historical range in the upper watersheds of the Central Valley and currently represent 1% of their historical abundance. The CVSC ESU has exhibited an increase in abundance (BRT 2003), demonstrated most dramatically in the Butte Creek population. The loss of upper-basin spawning and holding habitats due to dam construction and environmental degradation has resulted in the extirpation of most Central Valley spring-run populations, reducing ESU abundance, productivity, spatial structure, and diversity. Genetic risks lie in possible hybridization between straying FRH spring-run with local native stocks. There are two evolutionarily distinct groups of Central Valley spring-run (Hedgecock 2002). The southern Cascades populations are more closely related to each other than to their fall-run conspecifics. The northern Sierra spring-run are more closely related to their respective fall-run conspecifics than to other spring-run populations in the ESU, similar to the evolutionary pattern demonstrated in the Klamath-Trinity basin. ESU spatial structure has been reduced through the extirpation of 15 extant populations, including all spring-run populations in the San Joaquin basin. The FRH spring-run chinook salmon program is not part of the CVSC ESU.

## 30.4 LITERATURE CITED

BRT (West Coast Salmon Biological Review Team). 2003. Updated status of Federally listed ESUs of West Coast salmon and steelhead. Northwest Fisheries Science Center, Seattle, Washington; Southwest Fisheries Science Center, Santa Cruz Laboratory, Santa Cruz, California. July 2003.

CDFG (California Department of Fish and Game). 1998. A status review of the spring-run Chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento River drainage. A report to the Fish and Game Commission, candidate species status report 98-01. June 1998.

––. 2002. Sacramento River Spring-Run Chinook Salmon 2001 Annual Report. Prepared for the Fish and Game Commission. California Department of Fish and Game, Habitat Conservation Division, Native Anadromous Fish and Watershed Branch. October 2002.

––. 2003. California Department of Fish and Game letter response to the BRT Report. CDFG, Region II, Rancho Cordova, CA.

––. 2004. Grandtabs. Native Anadromous Fish and Watershed Branch. Revised April 26, 2004.

CDFG and NOAA Fisheries (National Marine Fisheries Service). 2001. Final report on anadromous salmonid fish hatcheries in California. Joint Hatchery Review Committee. December 2001.

Fisher, F. W. 1994. Past and present status of Central Valley Chinook salmon. Conserv. Biol. 8:870-873.

Fry, D. H. 1961. King salmon spawning stocks of the California Central Valley. 1940-1959. California Fish and Game 47(1): 55-71.

Hedgecock, D. 2002. Microsatellite DNA for the management and protection of California's Central Valley Chinook salmon (*Oncorhynchus tshawytscha*). Final report for the Amendment to Agreement No. B-59638. University of California at Davis, Bodega Marine Laboratory.

Mahoney, J. 1958. 1957 King salmon spawning population estimates for the Sacramento-San Joaquin River Systems. Calif. Dept. Fish and Game, Mar. Res. Br. 18pp.

––. 1960. 1959 King salmon spawning population estimates for the Sacramento-San Joaquin River Systems. Calif. Dept. Fish and Game, Mar. Res. Br. 14pp.

NOAA Fisheries (National Marine Fisheries Service). 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-35. February 1998.

––. 1999. FINAL RULE: Endangered and Threatened Species; Threatened Status for Two Chinook Salmon Evolutionarily Significant Units (ESUs) in California. September 16, 1999; 64 FR 50394.

SHAGG (Salmon and Steelhead Hatchery Assessment Group). 2003. Hatchery broodstock summaries and assessments for chum, coho, and Chinook salmon and steelhead stocks within evolutionarily significant units listed under the Endangered Species Act. Northwest Fisheries Science Center, Seattle, WA, and the Southwest Fisheries Science Center, La Jolla, CA. May 2003.

Yoshiyama, R. M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle. 2001. Historical and present distribution of Chinook salmon in the Central Valley drainage of California. In: Brown, R.L., editor. Fish Bulletin 179: Contributions to the biology of Central Valley salmonids. Volumne 1. Sacramento (CA): California Department of Fish and Game.